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On the Rotation of Saturn in 1894. By A. Stanley Williams.

The observations of spots in 1894 were made and reduced in the same manner and with the precautions described in my paper in the *Monthly Notices*, vol. liv. p. 298 *et seq.* The periods of rotation of the different spots have also been determined in the way indicated in that paper. These periods are based, therefore, upon Mr. Marth's Ephemeris contained in the *Monthly Notices*, vol. liv. p. 163.* The observations attributed to Herr Brenner are the result of measures of two drawings made with the 7-inch refractor of the Manora Observatory, and published in the *English Mechanic*, vol. lx. p. 364. These positions are necessarily only approximate, though they agree closely enough with the other observations to make the identification of the different spots certain. I have assumed the light interspaces between the dark markings shown by Herr Brenner just north of the ring to be identical with the bright equatorial spots. The observations of Mr. G. L. Brown, of Stirling, and Mr. H. MacEwen, of Glasgow, have been communicated to me direct by the respective observers.

The observations of 1894 are on the whole remarkably accordant, the agreement being even more satisfactory than it was in the preceding year. They are in fact so accurate that they have brought to light a rather remarkable peculiarity. On looking through the observations of the different spots it will be noticed as quite a usual thing for those of an individual spot to be best represented not by a uniform period of rotation, but by one with a continual change in its length. In other words, the observations when projected upon a chart are best represented by a slightly curved line, instead of by a straight one, as they should be if the motion of the spot had been uniform. As instances of this peculiarity the bright equatorial spots 1, 2, 5, 6, 8, 10, 11, 13, 15 and the dark northern spots I., II., III., IV., V., VI., VII., VIII., X., may be mentioned. Thus out of twenty-six spots eighteen show the peculiarity in question, which appears to be masked in the case of the remaining spots by the accidental errors of the observations, or from the latter being too few in number or too close together to show it. Only with spots IX. and XI. is there any decided tendency shown of a similar peculiarity, but in the opposite direction.

As to the cause of this rather remarkable feature, it hardly seems likely that it could have been due to a real physical change

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* In 1893 the period of rotation corresponding to the Ephemeris was inadvertently assumed to be $10^h\ 13^m{\cdot}64$, instead of $10^h\ 13^m{\cdot}636$, the more correct value. In consequence of this, all the rotation periods of that year contained in the paper referred to above should be diminished by $0^s{\cdot}2$.

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on *Saturn*, since the same variation is found both in the equatorial zone and in the zone of the dark northern spots, two regions situated at a great distance from each other and possessed moreover of greatly differing rates of rotation. It may perhaps, with more probability, be ascribed to a change in the personal equation of the observer, there being possibly a tendency for the transits to be observed later in the middle of a series of observations than at the ends, when the spots would be more difficult to observe.

In the tables of observations, the column headed T contains the G.M.T. of transit of the spot, and that headed T′ these times reduced to one date by means of the adopted rotation period of the spot, with, in the following column, the differences from the mean. The other columns explain themselves. The longitudes are derived from Mr. Marth's Ephemeris. The abbreviations used in the descriptive notes are as before : S = small, vS = very small, eS = exceedingly small, B = bright, mB = moderately bright, F = faint, vF = very faint, D = dark, v = very, e = exceedingly, m = moderately.

The Dark Spots in the Northern Hemisphere.

These dark spots were similar to those observed in 1893, and occupied the same situation on a conspicuous double belt in the planet's northern hemisphere. But in 1894 they were observed more frequently to project south of the dark belt into the bright equatorial zone, and to a greater extent. This peculiarity was noted independently by Messrs. Brenner, Brown, and MacEwen. The spots were not seen double so frequently as they had been in the preceding year.

Dark Spot I.

Date.	T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Mar. 4	14 31·6	327·6	1·5	10 43·4	+ 1·4	10 14 62·1	*a*
Apr. 18	10 42·3	53·0	2	42·3	− 0·1	66·1	*b*
27	10 1·3	72·6	1	46·4	+ 4·0	64·7	*c*
May 3	9 32·7	84·9	1	47·7	+ 5·3	63·7	*d*
June 13	9 21·3	154·4	2	32·1	−10·3	55·7	*e*

Description.—(*a*) S, mD, chiefly on south band of the double belt and projecting S. of it, much elong. N. and S. (*b*) vS, F. (*c*) S, F, much elong. N. and S. (*d*) S, mD. (*e*) S, F, elong. N. and S.

Mean period of rotation = $10^{h}\ 15^{m}\ 2^{s}{\cdot}0 \pm 1^{s}{\cdot}38$ (236 rotations). On three nights the spot was noted as being elongated in a north and south direction.

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Dark Spot II.

Date.	T.	Long.	Weight.	T'.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Feb. 20	16 1·3	321·5	2	12 38·1	− 4·6	10 14 62·1	*a*
Mar. 31	12 45·6	37·6	1	45·6	+ 2·9	58·1	*b*
Apr. 9	11 58·0	53·6	1	44·7	+ 2·0	57·3	*c*
21	10 53·7	74·3	2	42·4	− 0·3	56·3	*d*
June 1	(10 43·2)	145·4	...	(34·9)	(− 7·8)	...	*e*

Description.—(*a*) vS, eF, projecting south of belt. (*b*) Obs. by MacEwen. Described as a faint spot on the belt, with a very faint streak extending in a s.f. direction from it across the bright equat. zone. (*c*) eS, eF. (*d*) vS, vF. (*e*) Obs. by Brenner. Spot projected south of the belt into the bright equat. zone.

Mean period of rotation $= 10^{h}\ 14^{m}\ 58^{s}{\cdot}7 \pm 0^{s}{\cdot}97$ (140 rotations). On three nights an extension of the spot southwards into the bright equatorial zone was recorded by three different observers.

Dark Spot III.

Date.	T.	Long.	Weight.	T'.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Mar. 25	13 46·2	43·8	1	11 24·7	− 2·6	10 14 58·9	*a*
Apr. 18	11 41·0	87·5	0·5	25·4	− 1·9	58·4	*b*
21	11 28·4	94·6	1	28·4	+ 1·1	58·6	*c*
June 13	10 25·6	192·1	1	31·3	+ 4·0	56·2	*d*
25	9 20·9	211·0	1	26·6	− 0·7	54·7	*e*

Description.—(*a*) No description possible, def. bad. (*b*) vS, F. (*c*) vS, F. (*d*) Spot seemed plain and to project south of belt, but image dim through haze. (*e*) S, mD, perhaps projecting south of belt.

Mean period of rotation $= 10^{h}\ 14^{m}\ 57^{s}{\cdot}2 \pm 0^{s}{\cdot}57$ (215 rotations). The accordance of the observations is very satisfactory. On two nights the spot seemed to project south of the belt.

Dark Spot IV.

Date.	T.	Long.	Weight.	T'.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Feb. 20	17 40·5	19·8	1	12 36·7	− 3·3	10 14 60·4	*a*
Mar. 2	13 29·7	41·5	0·5	44·2	+ 4·2	57·9	*b*
16	15 37·0	64·8	2	41·5	+ 1·5	54·7	*c*
Apr. 18	12 40·1	122·1	2	40·1	+ 0·1	54·4	*d*
19	(9 9·3)	123·3	...	(39·5)	(− 0·5)	...	*e*
May 21	9 44·8	178·6	2	37·3	− 2·7	53·9	*f*

Description.—(*a*) vS, eF. (*b*) vS, vF. (*c*) vS, F. (*d*) vS, F. (*e*) Obs. by Brown. The spot projected distinctly into the bright equat. zone. Time from measures of a sketch. (*f*) Two eS, mD spots, the south one suspected to project into the equat. zone.

Mean period of rotation $= 10^{h}\ 14^{m}\ 55^{s}{\cdot}4 \pm 0^{s}{\cdot}73$ (210 rotations). The observations are in very satisfactory agreement.

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Dark Spot V.

Date.		T.		Long.	Weight.	T′.		Diff.	Period of Rotation.			
		h	m	°		h	m	m	h	m	s	
Feb.	3	16	52·0	28·0	0·5	13	63·1	+ 1·8	10	13	43·9	*a*
Mar.	2	14	14·0	67·5	1		60·5	− 0·8			45·6	*b*
	8	13	39·6	76·8	2		60·7	− 0·6			46·0	*c*
	22	15	53·3	103·7	3		70·0	+ 8·7			44·5	*d*
	29	11	45·2	112·4	0·5		67·1	+ 5·8			44·3	*e*
Apr.	1	11	11·8	107·5	1		50·9	− 10·4			44·8	*f*
	9	14	1·2	125·9	1		61·2	− 0·1			42·4	*g*
	21	12	50·6	142·8	3		59·0	− 2·3			43·4	*h*
May	12	10	50·8	174·1	3		57·9	− 3·4			44·9	*i*
	24	9	50·7	196·4	2		64·9	+ 3·6			47·9	*j*
	30	9	11·0	201·8	0·5		58·5	− 2·8			43·9	*k*

Description.—(*a*) vS, F, chiefly on south band of the double belt. (*b*) vS, vF. (*c*) vS, F. (*d*) vS, mD. (*e*) Def. confused, no description possible. (*f*) vS, mD, chiefly on south band. (*g*) vS, F. (*h*) vS, F. (*i*) Two eS, mD, spots lying N. and S. (*j*) vS, mD, much elong. N. and S. (*k*) eS, F, on south band only.

Mean period of rotation = $10^h\ 14^m\ 44^s{\cdot}8 \pm 0^s{\cdot}30$ (271 rotations). The observations are in very satisfactory agreement with the exception of those of March 22, 29, and April 1, and it is probable that even these apparently discordant observations were due to a temporary displacement of the spot. On two nights the spot was noted as being situated chiefly on the south band of the double belt, whilst on a third night it was only seen on this southernmost band. The descriptions on May 12 and 24 also agree well, poor definition on the latter night not having allowed the spot to be seen double.

Dark Spot VI.

Date.		T.		Long.	Weight.	T′.		Diff.	Period of Rotation.			
		h	m	°		h	m	m	h	m	s	
Apr.	1	11	47·0	128·1	1	11	47·0	− 0·9	10	14	45·2	*a*
	18	13	35·6	154·7	2		48·9	+ 1·0			43·4	*b*
	27	12	43·1	167·6	2		47·9	0·0			42·5	*c*

Description.—(*a*) No description possible, def. bad. (*b*) vS, F. (*c*) vS, F.

Mean period of rotation = $10^h\ 14^m\ 43^s{\cdot}4 \pm 0^s{\cdot}47$ (61 rotations). Observations very accordant.

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Dark Spot VII.

Date.	T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Mar. 17	13 38·2	120·0	2	13 40·9	− 3·5	10 14 45·9	*a*
23	(12 52·5)	122·5	1	(30·0)	(−14·4)	...	*b*
Apr. 21	13 46·4	175·6	3	46·4	+ 2·0	43·2	*c*
27	13 11·6	184·3	3	46·0	+ 1·6	43·1	*d*
May 21	10 54·2	219·4	0·5	44·8	+ 0·4	42·5	*e*
30	10 2·8	232·2	2	43·9	− 0·5	42·2	*f*

Description.—(*a*) vS, mD. (*b*) No description possible, def. bad. (*c*) S, F. (*d*) S, F. (*e*) Inconspicuous, but def. bad. (*f*) S, F.

Mean period of rotation = $10^{h}\,14^{m}\,43^{s}{\cdot}5 \pm 0^{s}{\cdot}42$ (173 rotations). The observations are very accordant with the exception of that of March 23, which was made under very unfavourable circumstances. On three nights the spot was recorded as S. on the scale of size, which is unusually large for a spot on *Saturn*.

Dark Spot VIII.

Date.	T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Feb. 18	16 32·5	90·1	0·5	11 42·8	− 2·7	10 14 53·0	*a*
Mar. 2	15 36·3	115·8	3	54·8	+ 9·3	48·7	*b*
Apr. 10	11 46·2	171·5	1	46·2	+ 0·7	42·9	*c*
May 1	9 42·6	201·0	1	40·7	− 4·8	42·0	*d*
4	9 28·0	207·0	0·5	42·9	− 2·6	43·6	*e*
10	(8 52·5)	215·1	...	(40·7)	(− 4·8)	...	*f*

Description.—(*a*) vS, F. (*b*) vS, F. (*c*) vS, mD. (*d*) S, mD. (*e*) S, F. (*f*) Very rough, spot a long way past transit when observed.

Mean period of rotation = $10^{h}\,14^{m}\,46^{s}{\cdot}5 \pm 1^{s}{\cdot}18$ (175 rotations).

Dark Spot IX.

Date.	T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Mar. 29	14 6·0	195·0	0·5	12 23·5	+ 0·6	10 15 51·8	*a*
Apr. 2	10 33·0	209·6	2	29·5	+ 6·6	47·8	*b*
28	12 19·6	278·6	3	19·6	− 3·3	40·4	*c*
May 4	11 54·2	292·7	1	14·4	− 8·5	30·1	*d*
7	11 57·1	308·9	1·5	27·4	+ 4·5	51·4	*e*
June 1	(7 0)	14·5	...	(17·8)	(− 5·1)	...	*f*

Description.—(*a*) Probably vS, F, but def. bad. (*b*) Two eS, mD, rather well def. spots. (*c*) Two eS, mD, rather well def. spots. (*d*) vS, F, rather well defined. (*e*) S, F. (*f*) Obs. by Brenner.

Mean period of rotation = $10^{h}\,15^{m}\,43^{s}{\cdot}7 \pm 2^{s}{\cdot}30$ (91 rotations). Observations not so accordant as usual. The descriptions on two nights, April 2 and 28, are identical and peculiar.

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Dark Spot X.

Date.		T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
		h m	°		h m	m	h m s	
Apr.	10	14 14·0	258·2	1	10 27·2	− 0·8	10 15 63·8	*a*
	17	10 35·3	284·1	1	35·3	+ 7·3	51·9	*b*
	28	13 13·3	310·1	0·5	21·4	− 6·6	32·5	*c*

Description.—(*a*) vS, F. (*b*) S, mD. (*c*) Probably S, F.

Mean period of rotation = $10^{\mathrm{h}}\ 15^{\mathrm{m}}\ 52^{\mathrm{s}}\cdot7 \pm 5^{\mathrm{s}}\cdot46$ (42 rotations).

Dark Spot XI.

Date.		T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
		h m	°		h m	m	h m s	
Feb.	18	17 54·1	138·0	2	16 54·9	+ 10·3	10 15 49·8	*a*
Mar.	2	17 5·3	168·0	3	45·4	+ 0·8	49·1	*b*
	8	16 44·5	185·3	1·5	44·5	− 0·1	47·2	*c*
	23	15 50·3	226·9	1	39·6	− 5·0	44·8	*d*
Apr.	1	15 20·3	253·3	0·5	39·1	− 5·5	42·5	*e*
	2	11 56·9	258·8	2	44·1	− 0·5	49·1	*f*

Description.—(*a*) vS, F, susp. dup. (*b*) vS, F. (*c*) vS, mD, probably dup. (*d*) No description possible, def. bad. (*e*) Same as *d*. (*f*) vS, F.

Mean period of rotation = $10^{\mathrm{h}}\ 15^{\mathrm{m}}\ 48^{\mathrm{s}}\cdot2 \pm 0^{\mathrm{s}}\cdot59$ (100 rotations). The observations are in satisfactory agreement with the exception of the first.

In 1893 the dark northern spots formed two distinct classes or groups, according to the lengths of their periods of rotation. The same peculiarity presents itself with regard to the spots observed in 1894, with the difference that we have here three quite distinct groups.

	No.	Period of Rotation.	No. of Rotations.
		h m s s	
Group A	I.	10 14 62·0 ± 1·38	236
	II.	10 14 58·7 ± 0·97	140
	III.	10 14 57·2 ± 0·57	215
	IV.	10 14 55·4 ± 0·73	210
Group B	V.	10 14 44·8 ± 0·30	271
	VI.	10 14 43·4 ± 0·47	61
	VII.	10 14 43·5 ± 0·42	173
	VIII.	10 14 46·5 ± 1·18	175
Group C	IX.	10 15 43·7 ± 2·30	91
	X.	10 15 52·7 ± 5·46	42
	XI.	10 15 48·2 ± 0·59	100

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Combining the different results, the following are the final values for the three groups :

h m s s
Group A. Mean Period of Rotation = 10 14 57·29 ± 0·68 (4 spots)
„ B. „ „ „ = 10 14 44·23 ± 0·30 (4 spots)
„ C. „ „ „ = 10 15 47·97 ± 0·60 (3 spots).

The different results composing each group agree closely *inter se*, as they did in 1893, and the different groups are quite distinct from each other. Hence the surface material of *Saturn* must have rotated in 1894, as in 1893, at widely differing rates in the same north latitude, but at different parts of the planet. Taking the date 1894 April 20 as epoch, the spots of group A extend from longitude 30° to 130° ; those of group B from longitude 140° to 200° ; and those of group C from longitude 240° to 360°, all according to Mr. Marth's Ephemeris. The extent in latitude of the northern spot zone is approximately from 17° N. to 37° N. It is worth noting that the periods of the four spots of group A become progressively less and less. This peculiarity is perhaps due to the influence of the more swiftly moving group B, the spots IV. and V. having approached very near one another towards the end of the observations.

The three groups being of nearly equal importance, the average period of rotation for the whole northern spot zone in 1894 may be found by taking the mean of the periods of these three groups. For 1893 I have taken the mean of the two groups A and B of that year. The following is a comparison of the results :

h m s
1893 Mean Rot. Per. = 10 14 44·7 (10 spots)
1894 „ „ „ = 10 15 9·8 (11 spots),

the difference being + $25^{\mathrm{s}}{\cdot}1$.

With respect to the identification of the spots of 1894 with those observed in 1893, it is not possible to do this with certainty as regards the individual spots on account of the long interval separating the two series of observations, and the great changes that have occurred. But it is otherwise with respect to certain of the *groups* of spots. Thus, group A of 1894 has very nearly the same rotation period as group B of 1893 ($10^{\mathrm{h}}\ 14^{\mathrm{m}}\ 57^{\mathrm{s}}{\cdot}3$ compared with $10^{\mathrm{h}}\ 15^{\mathrm{m}}\ 0^{\mathrm{s}}{\cdot}5$), and by calculating back the position of the former group, it appears that this group is in fact identical with the preceding part of group B, 1893, the spots which formed the following part of the last-named group having apparently disappeared.

Similarly group B of 1894 appears to be identical with group A of 1893, though there has been an increase in the period of rotation amounting to 15^{s}. Here also about half the spots of the last-named group seem to have disappeared.

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The Bright Equatorial Spots.

The bright equatorial spots of 1894 were similar in appearance and position to those observed in 1893. Owing to the ring system being more open, they were perhaps rather better seen than they had been in the latter year. A narrow dark belt, approximately marking the planet's equator, was frequently observed to cut across the bright spots, dividing them into two parts.

Bright Spot 1.

Date.	T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Feb. 18	15 35·4	56·6	2	13 24·7	+ 0·4	10 13 6·8	*a*
Mar. 2	13 39·7	47·4	3	23·8	− 0·5	8·2	*b*
16	14 54·1	39·7	1	28·0	+ 3·7	7·8	*c*
25	13 30·2	34·4	0·5	30·2	+ 5·9	6·5	*d*
Apr. 18	9 29·5	10·3	1	18·7	− 5·6	1·7	*e*
May 16	11 54·7	350·8	1	20·3	− 4·0	4·7	*f*
June 1	(6 7·6)	343·7	...	(27·8)	(+ 3·5)	...	*g*

Description.—(*a*) vS, F. (*b*) vS, F. (*c*) vS, mB, yellowish. (*d*) Probably vS, mB. (*e*) vS, mB. (*f*) vS, F. (*g*) Obs. by Brenner.

Mean period of rotation = $10^{h}\ 13^{m}\ 6^{s}{\cdot}5 \pm 0^{s}{\cdot}63$ (204 rotations). The spot was rather a bright one.

Bright Spot 2.

Date.	T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Mar. 8	13 33·8	73·4	2	11 47·8	0·0	10 12 58·4	*a*
16	15 32·7	62·3	2	40·0	− 7·8	63·8	*b*
Apr. 9	11 52·6	50·4	3	52·6	+ 4·8	64·0	*c*
18	10 25·9	43·4	2	52·9	+ 5·1	67·7	*d*
21	9 49·9	36·8	1	45·8	− 2·0	59·2	*e*
June 1	(7 0)	14·5	...	(63·8)	(+16·0)	...	*f*

Description.—(*a*) S, F, seen plainly. (*b*) vS, F, well seen. (*c*) S, F, plain. (*d*) vS, F, plain. (*e*) vS, mB, creamy white. (*f*) Obs. by Brenner.

Mean period of rotation = $10^{h}\ 13^{m}\ 3^{s}{\cdot}1 \pm 1^{s}{\cdot}09$ (103 rotations). The spot was rather a plain one.

Bright Spot 3.

Date.	T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Feb. 18	17 33·7	126·0	2	15 36·4	0·0	10 13 0·7	*a*
Mar. 2	15 35·9	115·6	3	35·9	− 0·5	1·2	*b*
22	15 45·5	99·1	1·5	36·9	+ 0·5	1·9	*c*

Description.—(*a*) eS, F. (*b*) vS, F. (*c*) vS, F.

Mean period of rotation = $10^{h}\ 13^{m}\ 1^{s}{\cdot}2 \pm 0^{s}{\cdot}21$ (75 rotations). Observations very accordant.

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Bright Spot 4.

Date.	T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Mar. 29	11 49·9	115·2	1	13 19·2	+ 1·0	10 12 40·6	*a*
Apr. 9	13 17·0	100·0	0·5	17·0	− 1·2	42·6	*b*
21	11 13·5	85·9	3	18·5	+ 0·3	44·8	*c*

Description.—(*a*) Probably mB. (*b*) eS, eF. (*c*) vS, vF.

Mean period of rotation = $10^{\mathrm{h}}\ 12^{\mathrm{m}}\ 43^{\mathrm{s}}\cdot 6 \pm 0^{\mathrm{s}}\cdot 84$ (54 rotations). Observations very accordant.

Bright Spot 5.

Date.	T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Mar. 2	16 58·0	163·7	3	11 37·6	− 4·1	10 12 41·9	*a*
26	12 47·5	134·3	0·5	43·5	+ 1·8	37·3	*b*
Apr. 1	11 41·3	124·8	1	41·3	− 0·4	37·9	*c*
18	12 8·6	103·7	2	45·4	+ 3·7	37·9	*d*
27	10 28·6	88·6	3	40·8	− 0·9	34·5	*e*
June 1	(7 52·4)	45·2	...	(48·9)	(+ 7·2)	...	*f*

Description.—(*a*) vS, F. (*b*) mL, mB. (*c*) No description possible, def. bad. (*d*) vS, F. (*e*) vS, mB, irregular on edges and ill def. with 320; well def. with 225. (*f*) Obs. by Brenner.

Mean period of rotation = $10^{\mathrm{h}}\ 12^{\mathrm{m}}\ 38^{\mathrm{s}}\cdot 1 \pm 0^{\mathrm{s}}\cdot 99$ (131 rotations). Spot rather a conspicuous one.

Bright Spot 6.

Date.	T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Mar. 8	16 50·0	188·5	1·5	9 24·2	− 0·4	10 12 40·6	*a*
26	13 41·1	165·7	3	26·6	+ 2·0	39·7	*b*
Apr. 19	9 27·0	133·7	1	27·0	+ 2·4	38·6	*c*
May 26	9 40·5	80·0	1	20·9	− 3·7	36·7	*d*
June 1	(8 44·5)	76·4	...	(28·4)	(+ 3·8)	...	*e*

Description.—(*a*) vS, F. (*b*) vS, F, plain. (*c*) Small and most difficult to see. It appeared only about $0''\cdot 5$ in diam. Obs. by Brown. (*d*) S, eF, irregular on edges, yellowish. (*e*) Obs. by Brenner.

Mean period of rotation = $10^{\mathrm{h}}\ 12^{\mathrm{m}}\ 39^{\mathrm{s}}\cdot 3 \pm 0^{\mathrm{s}}\cdot 49$ (185 rotations). Observations in excellent agreement. The spot was observed by three observers.

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Bright Spot 7.

Date.	T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Mar. 21	12 43·2	227·2	1	10 24·8	− 1·9	10 11 73·9	*a*
23	15 53·7	228·9	1	34·3	+ 7·6	54·8	*b*
26	15 5·5	215·2	1	20·7	− 6·0	91·6	*c*
29	14 36·3	212·8	1	26·1	− 0·6	81·5	*d*
Apr. 2	10 28·0	206·6	1	28·0	+ 1·3	80·8	*e*
10	12 18·3	190·4	4	26·4	− 0·3	75·0	*f*

Description.—(*a*) vS, mB, def. bad. (*b*) Probably mB, def. bad. (*c*) Inconspicuous, spot only glimpsed faintly, def. bad. (*d*) Inconspicuous, def. very bad. (*e*) S, F. (*f*) vS, mB, plain.

Mean period of rotation $= 10^{\rm h}\ 12^{\rm m}\ 15^{\rm s}\cdot8 \pm 2^{\rm s}\cdot76$ (47 rotations). The first four observations were made under very unfavourable conditions, definition on each night being bad. Considering this circumstance, the observations are in good agreement.

Bright Spot 8.

Date.	T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Feb. 20	15 13·3	293·4	3	13 4·4	− 0·6	10 12 23·7	*a*
Apr. 27	13 5·6	180·8	3	5·6	+ 0·6	23·2	*b*
May 12	10 18·0	154·9	1	5·1	+ 0·1	23·1	*c*

Description.—(*a*) vS, mB, plain. (*b*) vS, F. (*c*) S, mB, unusually plain.

Mean period of rotation $= 10^{\rm h}\ 12^{\rm m}\ 23^{\rm s}\cdot4 \pm 0^{\rm s}\cdot12$ (190 rotations). Observations very accordant.

Bright Spot 9.

Date.	T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Mar. 24	13 9·9	257·7	3	11 27·6	− 0·1	10 12 19·9	*a*
Apr. 2	11 27·5	241·5	0·5	27·5	− 0·2	20·0	*b*
May 1	9 23·5	189·8	1	28·0	+ 0·3	20·3	*c*

Description.—(*a*) vS, F. (*b*) vS, F. (*c*) Probably mB, def. bad.

Mean period of rotation $= 10^{\rm h}\ 12^{\rm m}\ 20^{\rm s}\cdot0 \pm 0^{\rm s}\cdot08$ (89 rotations). Observations remarkably accordant.

Bright Spot 10.

Date.	T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Feb. 20	16 28·5	337·5	3	14 8·6	− 0·4	10 12 23·5	*a*
Mar. 4	14 8·9	314·3	0·5	3·3	− 5·7	26·0	*b*
Apr. 2	12 17·3	270·7	1	12·1	+ 3·1	24·2	*c*
10	14 6·0	253·6	0·5	6·0	− 3·0	25·2	*d*
May 4	9 48·8	219·2	3	15·8	+ 6·8	27·1	*e*
7	9 9·0	210·3	0·5	9·3	+ 0·3	25·1	*f*
24	9 23·9	180·7	1	7·6	− 1·4	22·7	*g*
June 13	(9 0·0)	141·9	0·5	(13 58·9)	(−10·1)	...	*h*

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Description.—(*a*) vS, F, plain. (*b*) S, F, plain. (*c*) vS, vF ? def. bad. (*d*) vS, F. (*e*) vS, mB. (*f*) vS, vB, seen brightly. (*g*) vS, mB, white, well seen. (*h*) Probably vS, F, very rough obs.

Mean period of rotation $= 10^{\rm h}\ 12^{\rm m}\ 24^{\rm s}{\cdot}9 \pm 0^{\rm s}{\cdot}46$ (218 rotations). A plain spot.

Bright Spot 11.

Date.		T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
		h m	°		h m	m	h m s	
Feb.	3	16 31·5	16·0	0·5	9 43·7	− 4·7	10 12 27·8	*a*
Apr.	17	9 46·1	255·2	3	46·1	− 2·3	25·7	*b*
May	7	9 38·6	227·7	3	56·5	+ 8·1	25·2	*c*
June	13	9 31·0	160·1	2	47·3	− 1·1	23·3	*d*

Description.—(*a*) S, mB, plain. (*b*) vS, mB. (*c*) vS, F. (*d*) vS, mB, well def., plain.

Mean period of rotation $= 10^{\rm h}\ 12^{\rm m}\ 25^{\rm s}{\cdot}1 \pm 0^{\rm s}{\cdot}45$ (305 rotations). A bright spot.

Bright Spot 12.

Date.		T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
		h m	°		h m	m	h m s	
Mar.	16	12 54·2	329·3	2	9 26·6	+ 6·2	10 12 19·9	*a*
May	10	9 17·5	229·7	0·5	17·5	− 2·9	25·7	*b*
	12	12 17·3	224·9	2	15·4	− 5·0	28·3	*c*
	24	10 11·2	208·4	1	22·3	+ 1·9	30·7	*d*

Description.—(*a*) vS, F, yellowish. (*b*) vS, mB. (*c*) vS, F. (*d*) vS, vF.

Mean period of rotation $= 10^{\rm h}\ 12^{\rm m}\ 23^{\rm s}{\cdot}5 \pm 1^{\rm s}{\cdot}72$ (162 rotations).

Bright Spot 13.

Date.		T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
		h m	°		h m	m	h m s	
Feb.	3	17 39·7	56·0	1	10 41·9	− 2·3	10 12 22·6	*a*
	20	17 56·5	29·2	0·5	47·2	+ 3·0	19·7	*b*
Mar.	4	15 33·9	4·2	0·5	40·4	− 3·8	21·6	*c*
	21	15 44·5	334·2	0·5	40·4	− 3·8	23·2	*d*
Apr.	17	10 37·0	285·1	1	37·0	− 7·2	22·5	*e*
	28	12 12·8	274·6	3	52·6	+ 8·4	23·5	*f*
May	1	11 41·0	270·5	1	54·3	+ 10·1	23·4	*g*
	7	10 19·0	251·4	1	39·6	− 4·6	21·7	*h*
	10	9 54·2	251·3	4	48·3	+ 4·1	23·7	*i*
	30	9 27·5	211·5	4	40·5	− 3·7	17·0	*j*

Description.—(*a*) vS, vF. (*b*) vS, vF. (*c*) No description possible, def. bad. (*d*) Same as *c*. (*e*) vS, F, plain. (*f*) S, F, irregular on edges, plain.

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(*g*) No description possible, def. bad. (*h*) vS, vF. (*i*) eS, F, fading off and irregular on the edges. (*j*) vS, mB, fading off on edges.

Mean period of rotation $= 10^{h}\ 12^{m}\ 21^{s}{\cdot}6 \pm 0^{s}{\cdot}61$ (272 rotations). The observations are rather discordant, but this is due chiefly to the fact that the motion of the spot was evidently not uniform. The spot appears to have rotated rather more swiftly than would accord with the above period between February 3 and April 17. There then occurred a sudden shift to the east, producing between April 17 and 28 a difference of over a quarter of an hour in the time of transit, whilst subsequently to the latter date the former more rapid motion of the spot was resumed. The nature of the change closely resembles that which occurred in the case of spot No. 1 of 1893.* On three nights the spot was particularly noted as fading off on the edges, whilst on two nights it was seen to be irregular on the edges.

Bright Spot 14.

Date.	T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
May 4	11 35·5	281·8	0·5	10 30·1	+ 0·1	10 12 29·1	*a*
10	10 29·8	272·2	2	29·8	− 0·2	29·2	*b*
June 25	9 1·4	199·5	0·5	30·2	+ 0·2	29·3	*c*

Description.—(*a*) vS, vF. (*b*) vS, F. (*c*) vS, mB.

Mean period of rotation $= 10^{h}\ 12^{m}\ 29^{s}{\cdot}2 \pm 0^{s}{\cdot}03$ (122 rotations). Observations very accordant.

Bright Spot 15.

Date.	T.	Long.	Weight.	T′.	Diff.	Period of Rotation.	
	h m	°		h m	m	h m s	
Mar. 22	13 23·9	16·1	3	11 50·2	+ 0·2	10 12 31·6	*a*
Apr. 9	10 8·5	349·4	0·5	51·9	+ 1·9	31·1	*b*
May 7	11 53·0	306·5	2	53·0	+ 3·0	30·2	*c*
June 25	9 46·4	225·9	0·5	44·8	− 5·2	28·1	*d*

Description.—(*a*) vS, F. (*b*) vS, vF. (*c*) vS, F. (*d*) vS, F.

Mean period of rotation $= 10^{h}\ 12^{m}\ 30^{s}{\cdot}8 \pm 0^{s}{\cdot}40$ (223 rotations).

The foregoing bright equatorial spots fall into three distinct groups or classes, as under :

	No.	Period of Rotation.	No. of Rotations.
		h m s s	
Group *a*	1	10 13 6·5 ± 0·63	204
	2	10 13 3·1 ± 1·09	103
	3	10 13 1·2 ± 0·21	75

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* See *Monthly Notices*, vol. liv. p. 310.

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	No.	Period of Rotation.	No. of Rotations.
		h m s s	
Group *b*	4	10 12 43·6 ± 0·84	54
	5	10 12 38·1 ± 0·99	131
	6	10 12 39·3 ± 0·49	185
Group *c*	7	10 12 15·8 ± 2·76	47
	8	10 12 23·4 ± 0·12	190
	9	10 12 20·0 ± 0·08	89
	10	10 12 24·9 ± 0·46	218
	11	10 12 25·1 ± 0·45	305
	12	10 12 23·5 ± 1·72	162
	13	10 12 21·6 ± 0·61	272
	14	10 12 29·2 ± 0·03	122
	15	10 12 30·8 ± 0·40	223

The following are the mean values for the three groups :

	h m s s	
Group *a*. Mean Period of Rotation	= 10 13 1·69 ± 0·70	(3 spots)
,, *b*. ,, ,, ,,	= 10 12 40·03 ± 0·91	(3 spots)
,, *c*. ,, ,, ,,	= 10 12 25·83 ± 0·86	(9 spots).

These three groups are all quite distinct from one another. The two last spots of group *c*, Nos. 14 and 15, would appear to form a sub-group, differing somewhat from the remaining spots of this group. For the date 1894 April 20 the spots of group *a* extend from longitude 0° to 80° ; those of group *b* from longitude 80° to 160° ; and those of group *c* from longitude 160° to 360°. The limits of latitude of the equatorial spot zone are approximately 6° N. and 6° S.

In order to find the average period of rotation for the whole spot zone I have taken the mean of the results for these three groups, giving group *c* treble weight. The like result for 1893 has been got by taking the simple mean of group C and spot No. 4 of that year. The following then are the average rotation periods of the whole equatorial spot zone in the different years, the values for 1891 and 1892 being the approximate ones found by Mr. Marth.

	h m s	s
1891 Mean Period of Rotation	= 10 14 21·8	Diff. = 43·6
1892 ,, ,, ,,	= 10 13 38·2	Diff. = 45·8
1893 ,, ,, ,,	= 10 12 52·4	Diff. = 16·6
1894 ,, ,, ,,	= 10 12 35·8	

It would appear from the above figures that the rate of decrease in the length of the period is diminishing. Between 1891 and 1894 the decrease amounts to $1^{m}\ 46^{s}$. This difference means a very considerable increase in the velocity of motion of

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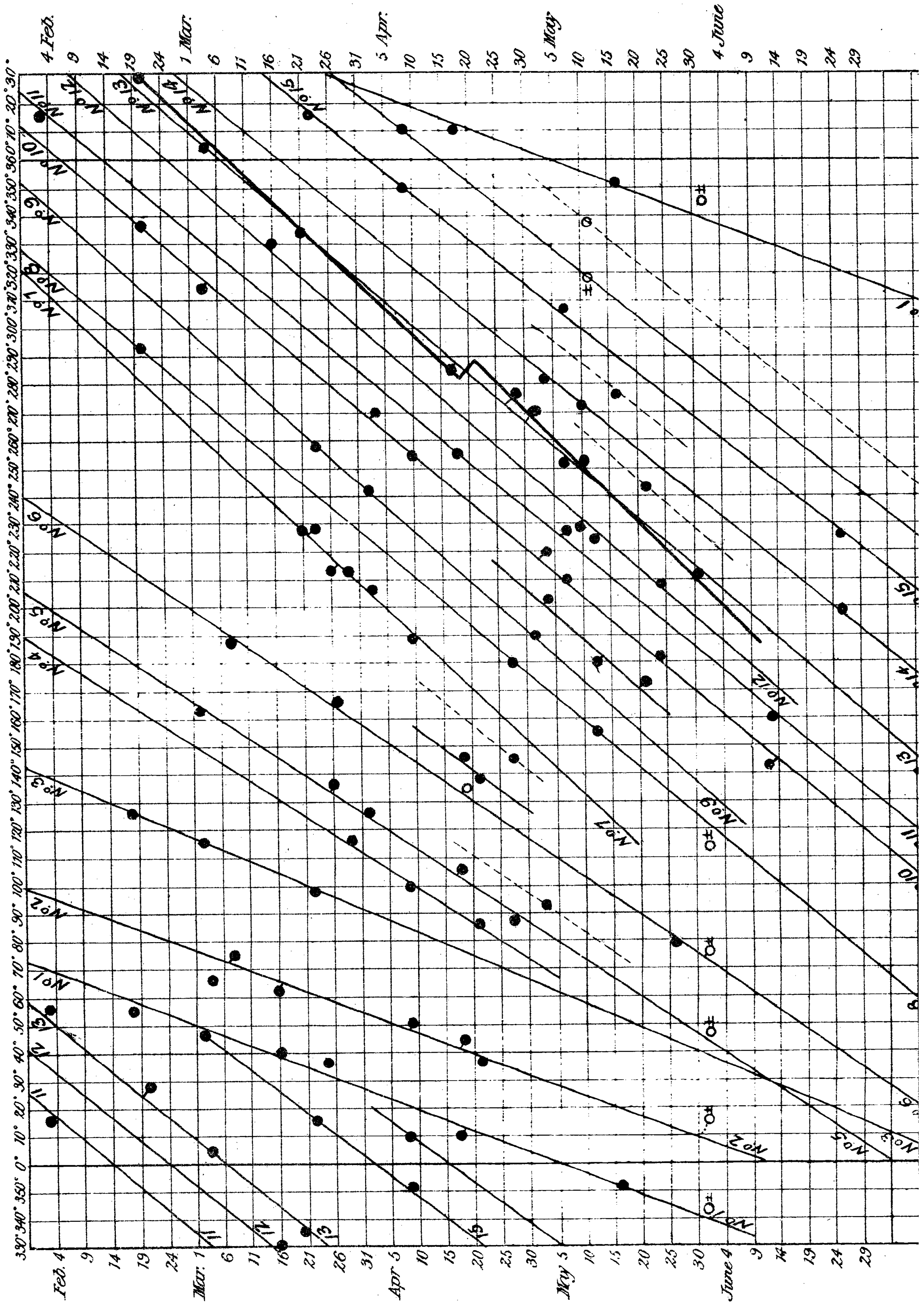
SATURN – Spot Chart for the Bright Equatorial Spots of 1894



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the surface material, amounting to 66 miles per hour. In other words, the great equatorial atmospheric current of *Saturn* was blowing 66 miles an hour more quickly in 1894 than it was in 1891.

As in the case of the dark northern spots, it does not seem possible to certainly identify any individual bright spot with those observed in 1893, though it is otherwise as regards the groups. Group *a* of 1894 has nearly the same period as group C of 1893 (10^h 13^m $1^s{\cdot}7$ compared with 10^h 12^m $59^s{\cdot}4$), and by calculating back its position, it appears that the former group is identical with the preceding portion of group C, 1893. The spots which formed the remaining part of the last-mentioned group (including amongst them the spots 1, 2, 3, and 5) had disappeared in 1894.

Group *b* of 1894 is also evidently identical with the region represented by spot 4 of the preceding year. It is even probable that spot 6 of 1894 is the same as spot 4 of 1893, a slight decrease having occurred in the length of its period in the interval. The position of the former spot calculated back to the early part of 1893 June agrees exactly with that of the latter.

The diagram, Plate 7, contains all the observations of the bright equatorial spots which have come to my knowledge, my own observations being represented by dots, and those of other observers by circles. In work of this kind everything, of course, depends upon the correct identification of the different spots. It will be seen from the diagram that the identifications are on the whole very satisfactory. Thus, in the cases of spots 3, 4, 5, 6, 8, 9, 14, and 15, the dots representing the observations are almost, where not actually threaded by the straight lines, drawn through the observations of each spot, whilst in no case do the discordances appear large enough to render the identifications doubtful. The observations are perhaps most discordant in the case of spot 13, but on the hypothesis that a sudden shift occurred in the position of this spot between April 17 and 28, they also come into very satisfactory agreement. This state of things has been indicated in the diagram by thick lines.

Micrometrical Measures of the Ball and Ring System of the Planet Saturn, and Measures of the Diameter of his Satellite Titan. Made with the 36-inch Equatorial of the Lick Observatory. By E. E. Barnard, A.M., Dr. Science.

From the decided advantage in the large scale of our great telescope, it would seem very important that a careful redetermination of the dimensions of the Saturnian Ball and Ring system should be made with it.

Recognising this, I have been anxious to do the work, and have taken advantage of the first opportunity that has occurred: this was the opposition of 1894.